great, but it would be out of place to recount them here.

We see that binary systems offer a rich field for the labors of the mathematician. Other subjects in astronomy are equally inviting, and I have no doubt that other sciences have as much to offer. An eminent psychologist, for example, has said that the time has come for a great mathematician to concern himself with psychological problems. There is a proverb to the effect that to him that is well shod the whole earth is covered with leather. And so the mathematician may walk where he pleases. What particular path he chooses is not a matter of great importance, but it is important that he be abroad and doing, and that he do not sit at home admiring his shoes.

Science has often been likened to a warfare, and such a simile as this naturally recurs to the mind at this time. We may think of science as at first occupying a small domain surrounded by the vast territories of the unknown. In the early days it was easier than now to add to this domain. A single bold spirit, starting out in almost any direction, could often wrest much from the adversary. But as the domain of science increases, so also do the extent and diversity of its boundaries. The more obvious points of vantage are already taken and the character of the warfare must change. The day of guerilla warfare is gone, it is now necessary to act in larger groups and for each man to be willing to serve at the side of others. This policy often requires the suppression of personal ambition, and deeds of individual heroism become less frequent; but great victories are to be won in either kind of warfare only if the soldier is imbued with such a spirit as this.

FRANK SCHLESINGER

ALLEGHENY OBSERVATORY OF THE
UNIVERSITY OF PITTSBURGH

THE PLACE OF FORESTRY AMONG NATURAL SCIENCES[1]

IN an old forest magazine, *Sylvan*, is a story about Germany's great poet, Karl von Schiller. Schiller, taking rest at Illmenau, Thuringen, met by chance a forester who was preparing a plan of management for the Illmenau forest. A map of the forest was spread out on which the cuttings for the next 220 years were projected and noted with their year number. By its side lay the plan of an ideal coniferous forest which was to have materialized in the year 2050. Attentively and quietly the poet contemplated the telling means of forest organization, and especially the plans for far distant years. He quickly realized, after a short explanation, the object of the work and gave vent to his astonishment: "I had considered you foresters a very common people who did little else than cut down trees and kill game, but you are far from that. You work unknown, unrecompensed, free from the tyranny of egotism, and the fruit of your quiet work ripens for a late posterity. Hero and poet attain vain glory; I would like to be a forester."

An opinion not unlike that held by Schiller before meeting with the forester still commonly prevails in scientific circles in this country. It is quite generally believed that foresters are pure empiricists; something on the order of gardeners who plant trees, of range-riders who fight forest fires, or lumbermen who cruise timber, carry on logging operations or manufacture lumber and other forest products; that for whatever little knowledge of a scientific character the forester may need in his work, he depends on experts in other branches of science; on the botanists for the taxonomy of the trees, on physicists, chemists, and engineers for the proper understanding of the physical, chemical

[1] Paper delivered before the Washington Academy of Sciences on December 3, 1914.

and mechanical properties of the wood; on the geologist and soil physicist for the knowledge of sites suitable for the growth of different kinds of trees; upon the plant pathologist for the diseases of trees; upon the entomologist for the insect enemies of the forest, and so on.

Such an impression is undoubtedly strengthened when the activities of such an organization as the Forest Service are considered. The placing under management of about 200 million acres of forest land has been an administrative problem of enormous magnitude. The administration of this vast public property involves many large industrial and economic questions, and affects intimately a number of varied and important interests: the lumber industry, the grazing industry, water power development, navigation, municipal water supplies, agricultural settlement, mining development and the railroads. In launching this first great public enterprise, undertaken in the face of very strong opposition, administrative activities appeared to overshadow research work. In this way doubtless many scientific men have gained the impression that forestry has little to do with science, which seeks for the causal relationship of things and for the establishment of laws and principles, that forestry is rather a patch work of miscellaneous knowledge borrowed from other sciences and assembled without particular system to help the practical administrator of forest property.

My endeavor in this paper will be to show that this impression is erroneous. While it is true that forestry as an art, as an applied science, utilizes results furnished by the natural and engineering sciences, while it is also true that the forester's activities—particularly during the pioneer period of establishing forest practise—may be largely administrative in character, there is nevertheless a fundamental forest science which has a distinctive place. As with all others the science of forestry owes its distinctive character to its correlation from a certain point of view of parts of certain other sciences, such as mathematics, botany, entomology, civil engineering and chemistry. But these are only auxiliary to the resultant science—forestry—which rests upon a knowledge of the life of the forest as such, and which therefore depends upon the discovery of laws governing the forest's growth and development.

It is in this field chiefly that foresters may claim some scientific achievement, some contribution to general science. Sciences do not develop out of curiosity; they appear first of all because there are practical problems that need to be solved, and only later become an aim in themselves. This has been equally true of the science of forestry. The object of forestry as an art is to produce timber of high technical quality. In pursuing this object, the forester very early observed that tall, cylindrical timber, comparatively free of knots, is produced only in dense stands, in forests in which the trees exert an influence upon each other as well as upon the soil and climate of the area occupied by them. He further discovered that the social environment produced by trees in a forest is an absolutely essential condition for the continuous natural existence of the forest itself. If the forester had not found forests in nature, he would have had to create forests artificially in order to accomplish his practical purpose, since it is only through the control and regulation of the natural struggle for existence between trees in the forest that the forester is capable of managing it for the practical needs of man. Thus from the very nature of his dealings with the forest the forester was forced from

the beginning to consider the forest not merely as an aggregation of individual trees but as communities of trees—tree societies—and first from purely utilitarian reasons, developed a science upon which the practise of silviculture now rests.

Forestry as a natural science, therefore, deals with the forest as a community in which the individual trees influence one another and also influence the character and life of the community itself. As a community the forest has individual character and form. It has a definite life history; it grows, develops, matures and propagates itself. Its form, development and final total product may be modified by external influences. By abuse it may be greatly injured and the forest as a living entity may even be destroyed. It responds equally to care and may be so molded by skillful treatment as to produce a high quality of product, and in greater amount and in a shorter time than if left to nature. The life history of this forest community varies according to the species composing it, the density of the stand, the manner in which the trees of different ages are grouped, the climatic and soil factors which affect the vigor and growth of the individual trees. The simplest form of a forest community is that composed of trees of one species and all of the same age. When several species and trees of different ages occupy the same ground, the form is more complex, the crowns overlapping and the roots occupying different layers of the soil. Thus, for instance, when the ground is occupied with a mixed stand of Douglas fir and hemlock, the former requiring more light, occupies the upper story, and because of its deeper root system extends to the lower lying strata of the soil. The hemlock, on the other hand, which is capable of growing under shade, occupies the understory, and having shallow roots utilizes largely the top soil.

There are forest communities, such for instance as those typical of northwestern Idaho, where western larch, Douglas fir, western white pine, white fir, western red cedar and hemlock will all grow together. Such a forest is evidently a very complex organism, the stability of which is based on a very nice adjustment between the different classes and groups occupying the same ground. Any change in one of these classes or groups must necessarily affect the other. If, for instance, in the Douglas fir-hemlock forest, the Douglas fir is cut out, the remaining hemlock trees are likely to die out because their shallow roots are left exposed to the drying effect of the sun and wind. It is only by a thorough understanding of such mutual adjustments that the forester is capable of intelligently handling the forest. With the great number of species that are found in this country, with the great variety in climatic and other physical factors which influence the form of the forest, it is self-evident that there are many forest communities, each with distinctive biological characteristics, which offer a wide field for scientific inquiry. Amid the great volume of administrative phases of the work in the Forest Service this main objective has never been lost sight of in handling the national forests. The Forest Service is now spending nearly $300,000 annually for research work, it maintains eight forest experiment stations and one thoroughly equipped forest products laboratory, and is doing this work solely to study the fundamental laws governing the life of the forest and their effect upon the final product—wood.

Forestry may be called tree sociology and occupies among natural sciences the same position as sociology among humanistic sciences. Sociology may be based upon the physiological functions of man as a biological individual. A physician, however, is not a sociologist, and social

phenomena can be understood and interpreted only in the light of sociological knowledge. So also with forestry. Forestry depends upon the anatomy and physiology of plants, but it is not applied anatomy and physiology of plants. With foresters, anatomy and physiology of plants is not the immediate end but enters only as one of the essential parts without which it is impossible to grasp the processes that take place in the forest. As the science of tree societies, forestry really is a part of the larger science dealing with plant associations, yet its development was entirely independent of botanical geography. When the need arose for the rational handling of timberlands, no science of plant association was in existence. Foresters were compelled to study the biology of the forest by the best methods available; they used the general scientific methods of investigation and developed their own methods when the former proved inadequate. I am frank to admit that the present knowledge of plant associations in botany has not yet reached a point where foresters could leave wholly to botanists the working out of the basic facts about the life of the forests which are needed in the practise of forestry. When the general science of plant associations has reached a higher state of development, the two may possibly merge, but not until then.

In developing the science of tree associations, the forester has been unquestionably favored by the fact that the forests, being the highest expression of social plant life, afford the best opportunity for observing it.

The reason for the ability of forest trees to form most highly organized plant societies lies in their mode of growth. Each annual ring of growth, together with the new leaves that appear every year, are in reality new colonies of cells. Some of the cells die toward the end of the vegetative season; others continue to live for a number of years. When the conditions of life in a forest have changed for a certain tree; when, for instance, from a dominant tree it became a suppressed one, the new colonies of cells formed during that year, and which sustain the life of that tree, are naturally adapted to these new conditions. The same is true when a suppressed tree, through some accident to its neighbors, comes into full enjoyment of light. The last annual growth is at once capable of taking advantage of the new situation created in the forest. Therefore, as long as the tree can form annual rings, it possesses the elasticity and adaptability essential for trees living in dense stands. It is only when a tree is suppressed to a point when it can not form new growth that it dies and is eliminated from a stand. Because of the fact that the forest is the highest expression of social plant life, the foresters occupy the strategic position from which they command vistas accessible only with difficulty to other naturalists. In this lies the strength of forestry, its peculiar beauty, and the debt which natural science owes to it. It is a significant fact, although, of course, only of historic importance, that, according to Charles Darwin[2] himself, it was "an obscure writer on forest trees who, in 1830, in Scotland (that is, 29 years before the 'Origin of Species' was published), most expressly and clearly anticipated his views on natural selection in a book on Naval Timber and Arboriculture." For the same reason it was foresters, who, long before the word "ecology" was coined, have assembled a vast amount of material on the life of the forest as a plant association—the basis of their silvicultural practise. Warming, Schimper, and other early writers on ecology, borrowed most of their

[2] "Origin of Species."

proofs and examples from the facts established by the foresters, and the forest literature of to-day is still practically the only one which contains striking examples of the application of ecology to the solution of practical problems.

One discovery recently made at the Wind River forest experiment station in Oregon comes particularly to my mind. In northwestern Idaho where the western white pine is at its optimum growth and is greatly in demand by the lumberman, our former method of cutting was to remove the main stand and leave seed trees for the restocking of the ground. In order to protect the seed trees from windfall, they were left not singly but in blocks, each covering several acres. The trees left amounted often to from 10 to 15 per cent. in volume of the total stand, and since they could not be utilized later they formed a fairly heavy investment for reforesting the cut-over land. A study of the effect of these blocks of seed trees upon natural reforestation has proved that they can not be depended upon, at least within a reasonable time, to restock naturally the cut-over land. The distance to which the seed is scattered from these seed trees is insignificant compared with the area to be reforested. Splendid young growth, however, is found here and there on cut-over land, away from any seed trees, where the leaf litter is not completely burned. It is evident, therefore, that the seed from which this young growth originates must have come from a source other than the seed trees. The study of the leaf litter in a virgin stand showed that the latter contained on the average from one to two germinable seeds per square foot. Some of the seed found was so discolored that it must have been in the litter for a long time. Thus it was discovered that the seed of the western white pine retains its vitality for years while lying in the duff and litter beneath the mature stands, and then germinates when the ground is exposed to direct light by cutting. It was found similarly that in old Douglas fir burns, where the leaf litter was not completely destroyed, the young growth invariably sprung up from seed that had escaped fire and had been lying dormant in the ground. Should a second fire go through the young stand before it reaches the bearing stage, the land may become a complete waste, at least for hundreds of years, although there may be seed trees left on the ground. This conclusively proves that the young growth comes from the seed stored in the ground before cutting took place and not from the seed scattered after cutting by the seed trees left.

The wonderful capacity of the leaf litter and duff of the cool, dark forests of the Northwest to act as a storage medium for the seed until favorable conditions for its germination occur is confined not only to the Douglas fir and western white pine but to the seed of other species which often grow together with them, such as Noble fir, amabalis fir, western red cedar and hemlock. The subsequent appearance of other species in a Douglas fir or western white pine stand depends apparently to a large extent upon the seed stored in the ground at a time when the original forest still existed. This discovery revolutionizes our conception of the succession of forest stands, since it shows that the future composition of the forest is determined by the seed stored in the leaf litter; and the appearance of seedlings first of one species and then of another results simply from the differences in the relative endurance of seed of the different species that are lying in the ground. Besides being of scientific importance this discovery has also a great practical significance. It accentuates the disastrous consequence of a second fire in an old burn because no more seed remains in the ground while the capacity of the few

seed trees that may be on the burn is very limited in restocking the ground. This discovery enabled the service to change materially the present methods of cutting in the white pine and Douglas fir forests, to the mutual advantage of the government and of the logging operators.

I shall give briefly a few other illustrations of the life of the forest which stamp it as a distinct plant society.

The first social phenomenon in a stand of trees is the differentiation of individuals of the same age on the basis of differences in height, crown development and growth, the result of the struggle for light and nourishment between the members of the stand. A forest at maturity contains scarcely 5 per cent. of all the trees that have started life there. Yet the death of the 95 per cent. is a necessary condition to the development of the others. The process of differentiation into dominant and suppressed trees takes place particularly in youth and gradually slows down toward maturity. Thus, in some natural pine forests, during the age between 20 to 80 years, over 4,000 trees on an acre die; whereas at the age between 80 and 100 only 300 trees die. With some trees this natural dying out with age proceeds faster than with others. Thus in pine, birch, aspen, and all other species which demand a great deal of light, the death rate is enormous. With spruce, beech, fir, and species which are satisfied with less light, this process is less energetic. The growing demand for space with age by individual trees in a spruce forest may be expressed in the following figures:

	Sq. Ft.
At 20 years of age	4
At 40 years of age	34
At 60 years of age	70
At 80 years of age	110
At 100 years of age	150

If we take the space required by a pine at the age between 40 and 50 years as 100; then for spruce at the same age it will be 87; for beech 79; and for fir 63. This process of differentiation is universal in forests everywhere.

Another peculiarity that marks a tree community is the difference in seed production of trees which occupy different positions in the stand. Thus if the trees in a forest are divided into five classes according to their height and crown development, and if the seed production of the most dominant class is designated as 100, the seed production for trees of the second class will be 88; for the third class, 33; for the fourth class only .5 per cent., while the trees of the fifth class will not produce a single seed, although the age of all these trees may be practically the same. The same struggle for existence, therefore, which produced the dominant and suppressed trees works toward a natural selection, since only those which have conquered in the struggle for existence, and are endowed with the greatest individual energy of growth, reproduce themselves.

In a forest there is altogether a different climate, a different soil and a different ground cover than outside of it. A forest cover does not allow all the precipitation that falls over it to reach the ground. Part of the precipitation remains on the crowns and is later evaporated back into the air. Another part, through openings in the cover, reaches the ground, while a third part runs down along the trunks to the base of the tree. Many and exact measurements have demonstrated that a forest cover intercepts from 15 to 80 per cent. of precipitation, according to the species of trees, density of the stand, age of the forest, and other factors. Thus pine forests of the north intercept only about 20 per cent., spruce about 40 per cent., and fir nearly 60 per cent. of the total precipitation that falls in the open. The amount that runs off along the trunks in some species is very

small—less than 1 per cent. In others, for instance beech, it is 5 per cent. Thus if a certain locality receives 50 inches of rain, the ground under the forest will receive only 40, 30 or 20 inches. Thus 10, 20 and 30 inches will be withdrawn from the total circulation of moisture over the area occupied by the forest. The forest cover, besides preventing all of the precipitation from reaching the ground, similarly keeps out light, heat and wind. Under a forest cover, therefore, there is altogether a different heat and light climate, and a different relative humidity than in the open.

The foliage that falls year after year upon the ground creates deep modification in the forest soil. The changes which the accumulation of leaf litter and the roots of the trees produce in the soil and subsoil are so fundamental that it is often possible to determine centuries after a forest has been destroyed, whether the ground was ever occupied by one.

The effect which trees in a stand have upon each other is not confined merely to changes in their external form and growth it extends also to their internal structure. The specific gravity of the wood, its composition, and the anatomical structure which determines its specific gravity differ in the same species, and on the same soil, and in the same climate, according to the position which the tree occupies in the stand. Thus in a 100-year-old stand of spruce and fir the specific gravity of wood is greatest in trees of the third crown class (intermediate trees). The ratio of the thick wall portion of the annual ring to the thin wall of the spring wood is also different in trees of different crown classes. The difference in the size of the tracheids in trees of different crown classes may be so great that in one tracheid of a dominant tree there may be placed three tracheid cells of a suppressed tree. The amount of lignin per unit of weight is greater in dominant trees than in suppressed trees.

Forest trees in a stand are thus influenced not only by the external physical geographical environment, but also by the new social environment which they themselves create. For this reason forest trees assimilate, grow and bear fruit differently and have a different external appearance and internal structure than trees not grown in a forest.

Forestry, unlike horticulture or agriculture, deals with wild plants scarcely modified by cultivation. Trees are also long-lived plants; from the origin of a forest stand to its maturity there may pass more than a century. Foresters, therefore, operate over long periods of time. They must also deal with vast areas; the soil under the forest is as a rule unchanged by cultivation and most of the cultural operations applicable in arboriculture or agriculture are entirely impracticable in forestry. Forests, therefore, are lagely the product of nature, the result of the free play of natural forces. Since the foresters had to deal with natural plants which grew under natural conditions, they early learned to study and use the natural forces affecting forest growth. In nature the least change in the topography, exposure or depth of soil, etc., means a change in the composition of the forest, in its density, in the character of the ground cover, and so on. As a result of his observations, the forester has developed definite laws of forest distribution. The forests in the different regions of the country have been divided into natural types with corresponding types of climate and site. These natural forest types, which by the way were also developed long before the modern conception of plant formations came to light, have been laid at the foundation of nearly all of the practical work in the woods. A

forest type became the silvicultural unit which has the same physical conditions of growth throughout and therefore requires the same method of treatment. The manner of growth and the method of natural regeneration once developed for a forest type, hold true for the same type no matter where it occurs. After the relation between a certain natural type of forest and the climate and topography of a region has been established, the forest growth becomes the living expression of the climatic and physical factors of the locality. Similarly, with a given type of climate and locality it is possible for the forester to conceive the type of forest which would grow there naturally. The forester, therefore, may speak of the climate of the beech forest, of the Engelmann spruce forest, of the yellow pine forest. Thus, if in China, which may lack weather observations, we find a beech forest similar to one found in northern New York, we can be fairly certain of the climatic similarities of the two regions. More than that, a type of virgin forest growth may serve as a better indication of the climate of a particular locality than meteorological records covering a short number of years. A forest which has grown on the same ground for many generation is the result not of any exceptional climatic cycle, but is the product of the average climatic conditions that have prevailed in that region for a long time. It expresses not only the result of one single climatic factor, but is the product of all the climatic and physical factors together. Similarly, the use of the natural forest types for determining the potential capacity of the land occupied by them for different purposes is becoming more and more appreciated. When the climatic characteristics of a certain type of forest, for instance those of Engelmann spruce in the Rocky Mountains, is thoroughly established, the potential capacity of the land occupied by it for agriculture, grazing, or other purposes is also largely determined.

Observations of the effect of climate upon forest growth naturally brought out facts with regard to the effect of forests upon climate, soil and other physical factors and led to the development of a special branch of meteorology, known as forest meteorology, in which the foresters have taken a prominent part. While there are some phases in forest meteorology which still allow room for disagreement, some relationships established by foresters are widely accepted. One of these is the effect which forests have upon local climate, especially that of the area they occupy and of contiguous areas. Every farmer who plants a windbreak knows and takes advantage of this influence. Another relation is that between the forest and the circulation of water on and in the ground, a relation which plays such an important part in the regimen of streams. Still a third one, as yet beyond the possibility of absolute proof, is the effect of forests in level countries, in the path of prevailing winds, upon the humidity and temperature of far-distant regions lying in their lee.

If in the field of botany the forester has contributed to the progress of botanical geography and in the realm of meteorology has opened new fields of investigation, his influence in wood technology has been in changing entirely the attitude of engineers, physicists and chemists in handling wood products. The methods of studying the physical, mechanical and chemical properties of wood were, of course, those used in engineering by chemists and physicists; but the forester has shown that wood, unlike steel, concrete or other structural material, is subject to altogether different laws. Wood, he has shown, is not a homogeneous product, but is greatly influenced by the

conditions in the stand from which it comes. Were it not, therefore, that mechanical properties can be tied up with some definite forest conditions and correlated with some readily visible expression of tree growth, such as the number of rings per inch or the specific gravity of the wood, timber would be too much of an indefinite quantity for architects and other users of wood to handle with perfect safety. To find such a relation is just what the foresters have been attempting to do and most of the studies of the strength of wood have been with the view of establishing certain relations between the mechanical, physical and anatomical properties of the wood. Some of these relations I may mention here.

One of the earliest relations which foresters have established with a fair certainty is that between the specific gravity of the wood and its technical qualities. Some of the foresters even go so far as to claim that the specific gravity of wood is an indicator of all other mechanical properties and that the strength of wood increases with the specific gravity, irrespective of the species and genus. In other words, the heavier the wood, all other conditions being equal, the greater its strength. Even oak, which formed apparently an exception, has been recently shown to follow the same law. If there is still some doubt that the specific gravity of wood can be made a criterion of all mechanical and technical properties of wood, the correlation between the specific gravity and the resistance to compression end-wise (parallel to the grain) is apparently beyond question. Thus by the specific gravity the resistance to compression end-wise can be readily determined. The compression end-wise equals 1,000 times the specific gravity minus 70, when the moisture contents of the wood is 15 per cent., or $C = 1{,}000S - 70$.

Since in construction work the most desirable wood is the one which possesses the highest strength at a given weight, the ratio between the compression strength and the specific gravity was found to express most clearly the strength of wood. This ratio, however, increases with the increase in the specific gravity, a fact which further substantiates the law that the specific gravity of wood determines its mechanical properties.

Another relation which has been fairly established is that between the resistance to compression end-wise and the bending strength of timber. (By the resistance compression end-wise, therefore, the bending strength of timber can be determined.)

One of the other properties of wood, namely hardness, was found to have a definite relation to the bending and compression strength of wood and this fact tempts the conclusion that by hardness alone all other mechanical properties can be determined. The test for hardness is very simple: it can be made even by a small manufacturer and therefore the whole problem of wood testing would be greatly simplified. Hardness was also found to have a definite relation to the proportion of the summer wood in the annual ring, and consequently to the specific gravity of the wood. The specific gravity of wood is determined by its anatomical structure, by the proportion of fibro-vascular bundles, their thickness and length, the proportion of thick-walled cells, medullary rays, etc. The anatomical structure in its turn is probably determined by the combination of two factors—the amount of nourishment in the soil and the intensity of transpiration. The mechanical properties of wood come, therefore, within the control of the forester who raises and cares for the forest.

There is another field of scientific endeavor in which foresters in this country may claim some credit. This is in the field

of forest mathematics. One unfamiliar with forest growth can hardly realize the difficulties in the way of measuring the forest crop, the amount of wood produced in a forest composed, for instance, of many different species, sizes and ages. If a tree resembled any geometric body, such as a truncated cone, or an Appolonian paraboloid, it would be a simple matter to determine its contents by applying the formula for such body. But a tree's form does not coincide with that of any known geometric body, so that it would seem that the only possible way of determining the contents of the trees forming a forest would be by measuring each single tree. Evidently this would be an entirely impracticable task.

The common practise of determining the contents of trees either in board measure or in cubic feet is to measure a large number of trees of a given species in a given locality and apply the average figures to the trees of the same diameters and heights within that locality. Since there are, however, a great many species of trees in this country, some of which have a very wide geographic range, this method necessarily involves the preparation of a large number of local volume tables and hence the measurement of hundreds of thousands of trees. The measurement of the taper of a large number of trees has shown that there are certain critical points along the stem of a tree, the ratio between which expresses the form of the tree in a sufficiently accurate manner. It was found that trees having the same total height, the same diameter breast-high ($4\frac{1}{2}$ feet from the ground), and the same ratio between the diameter at half the height of the tree and the diameter breast-high, must invariably have the same cubic contents irrespective of the species of the tree or the region in which it grows. Thus whether it be a Scotch pine of northern Sweden, a yellow pine of Arizona, a mahogany of the tropics, or a scrubby birch of the Arctic Circle, the volume of the tree may be expressed by means of one simple relationship. The discovery of this very simple relation provides for the first time a basis for the construction of a universal volume table. The mathematicians of the earlier period sought in vain to find a formula by which the cubic contents of a tree could be expressed. What the mathematicians failed to develop by the deductive method, foresters have found by the inductive method. With a reliable table for converting cubic measure into board measure for trees of different sizes the universal volume table expressed in cubic feet could be translated into a universal table expressed in board feet, which is the measure peculiar to this country.

There is another contribution of which I am somewhat hesitant to speak for it is not a contribution to pure science, if by science is meant only the physical or natural sciences. Since, however, it touches the interests of a large number of people, I may be forgiven if I say a few words about it. It is a contribution to what one economist has aptly called the "science of social engineering." The transfer of the forest reserves in 1905 to the Department of Agriculture marked a new departure in the national economic life. It recognized the new principle that the nation's resources should be managed by the nation and directly in the interests of the whole people; it recognized that these resources should be developed collectively rather than individually and indirectly. Nearly ten years have now passed since the inauguration of this policy. The record of what has been accomplished and the manner in which many of the problems have been approached and solved must unquestionably be considered a contribution to the methods by which similar problems may be handled by the nation in the

future. In the administration of the national forests there is being developed gradually what I believe to be a truly scientific system for attaining a concrete economic end, a system of controlling certain correlated industries with a single purpose in view—the maximum of the welfare of the nation as a whole. In spite of many mistakes which we have undoubtedly made and which we have attempted to correct as we went along, in spite of the lack of practise and experience in solving the problems at hand, this new policy, it seems to me, has already proved entirely safe and workable.

HENRY S. GRAVES

U. S. FOREST SERVICE

MATHEMATICS, ASTRONOMY AND PHYSICS AT THE CALIFORNIA MEETING

A JOINT session of the American Mathematical Society, the American Astronomical Society and Section A of the American Association for the Advancement of Science will be held on Tuesday, August 3, at the University of California, for the presentation of two addresses:

The Human Significance of Mathematics: by Professor C. J. Keyser, Columbia University, New York.

The Work of a Modern Observatory: by Dr. George E. Hale, Mount Wilson Solar Observatory.

On Friday, August 6, the American Astronomical Society and others interested in astronomical research will make an excursion to the Lick Observatory, Mount Hamilton, near San José. The director of the Mount Wilson Solar Observatory, near Pasadena, extends a cordial invitation to men of science interested in astronomical and physical research to visit the observatory either before or after the San Francisco meeting of the association.

Physicists are invited to attend a joint session for mathematics, astronomy and physics on Tuesday, August 3. One session of the meetings devoted to physics will give consideration to recent spectroscopical investigations.

On the occasion of the visit of the association to Stanford University on Wednesday, August 4, Professor Harris J. Ryan will give demonstrations with high potential electric currents in the new laboratory which has been equipped for high potential experimentation.

SCIENTIFIC NOTES AND NEWS

DR. CHARLES H. HERTY, professor of chemistry in the University of North Carolina, has been elected president of the American Chemical Society for the year 1915. The address of the retiring president, Professor Theodore W. Richards, of Harvard University, written for the Montreal meeting of the society which was abandoned on account of the war, has been printed in the *Journal* of the American Chemical Society for December. The subject is "The Present Aspect of the Hypothesis of Compressible Atoms."

THE Perkin medal of the Society of Chemical Industry will be conferred on Dr. Edward Weston on the evening of January 22, at the Chemist's Club, New York City. Dr. Charles F. Chandler will present the medal and an address will be made by Dr. L. H. Baekeland.

ON January 20, 1915, the Medical Society of the District of Columbia held a memorial meeting in honor of the late Dr. A. F. A. King, who died on December 13, 1914. The following appreciations were presented: In Memoriam, Resolutions by Committee, Dr. D. S. Lamb; Biographical Sketch, Dr. Henry D. Fry; Dr. King as an Author, Dr. Barton Cooke Hirst; Doctor King on Mosquitoes and Malaria, Dr. L. O. Howard; Doctor King as a Teacher, Dr. Sterling Ruffin; Doctor King as Dean of the Medical School, Dr. D. K. Shute; Personal Characteristics, Dr. A. R. Shands.

THE Rev. Sir John Twisden, formerly professor of mathematics in the Staff College of the British army, has died at the age of nearly ninety years.

M. ALFRED FOURNIER, formerly professor of dermatology and syphiligraphy at the University of Paris, has died at the age of eighty-two years.